

## Chapter 13

$$1. \text{Rate}_{\text{neon}} = \sqrt{\frac{20.2 \text{ g/mole}}{28.0 \text{ g/mole}}} = \sqrt{0.721} = 0.849$$

$$2. \text{Rate}_{\text{carbon dioxide}} = \sqrt{\frac{44.0 \text{ g/mole}}{28.0 \text{ g/mole}}} = \sqrt{1.57} = 1.25$$

$$3. \text{Rearrange Graham's law to solve for Rate}_A.$$

$$\text{Rate}_A = \text{Rate}_B \times \frac{\text{molar mass}_B}{\text{molar mass}_A}$$

$$= 3.6 \text{ mol/min} \times \frac{1.05}{0.71} = 5.0 \text{ mol/min}$$

$$4. P_{\text{hydrogen}} = P_{\text{total}} - P_{\text{helium}}$$

$$5. P_{\text{total}} = 5.00 \text{ kPa} + 4.56 \text{ kPa} + 3.02 \text{ kPa} + 1.20 \text{ kPa} = 161 \text{ mm Hg}$$

$$6. P_{\text{carbon dioxide}} = 30.4 \text{ kPa} - (16.5 \text{ kPa} + 3.7 \text{ kPa}) = 30.4 \text{ kPa} - 20.2 \text{ kPa} = 10.2 \text{ kPa}$$

$$= 13.78 \text{ kPa}$$

$$7. T_1 = 80.0^\circ\text{C} + 273 = 353 \text{ K}$$

$$605 - 273 = 330^\circ\text{C}$$

$$T_2 = \frac{T_1 V_2}{V_1} = \frac{(362 \text{ K})(1.12 \text{ L})}{0.67 \text{ L}} = 605 \text{ K}$$

$$T_2 = 30.0^\circ\text{C} + 273 = 303 \text{ K}$$

$$V_2 = \frac{V_1 T_2}{T_1} = \frac{(3.00 \text{ L})(303 \text{ K})}{250 \text{ K}} = 2.58 \text{ L}$$

$$T_2 = 0.00^\circ\text{C} + 273 = 273 \text{ K}$$

$$8. T_1 = 25.0^\circ\text{C} + 273 = 298 \text{ K}$$

$$V_2 = \frac{V_1 T_2}{T_1} = \frac{(0.620 \text{ L})(273 \text{ K})}{0.00^\circ\text{C} + 273} = 0.57 \text{ L}$$

$$T_2 = 30.0^\circ\text{C} + 273 = 303 \text{ K}$$

$$9. T_1 = 30.0^\circ\text{C} + 273 = 303 \text{ K}$$

$$T_2 = \frac{T_1 V_2}{V_1} = \frac{(303 \text{ K})(201 \text{ kPa})}{125 \text{ kPa}} = 487 \text{ K}$$

$$487 \text{ K} - 273 = 214^\circ\text{C}$$

$$10. T_1 = 25.0^\circ\text{C} + 273 = 298 \text{ K}$$

$$T_2 = 37.0^\circ\text{C} + 273 = 310 \text{ K}$$

$$P_2 = \frac{P_1 T_2}{T_1} = \frac{(1.88 \text{ atm})(310 \text{ K})}{298 \text{ K}} = 1.96 \text{ atm}$$

$$11. T_2 = 36.5^\circ\text{C} + 273 = 309.5 \text{ K}$$

$$T_1 = \frac{T_2 P_1}{P_2} = \frac{(309.5 \text{ K})(1.12 \text{ atm})}{256 \text{ atm}} = 135 \text{ K}$$

$$12. T_1 = 0.00^\circ\text{C} + 273 = 273 \text{ K}$$

$$135 \text{ K} - 273 = -138^\circ\text{C}$$

$$13. T_1 = 22.0^\circ\text{C} + 273 = 295 \text{ K}$$

$$The temperature must be lowered by 21^\circ\text{C}.$$

$$711 \text{ torr} - 660 \text{ torr} = 51 \text{ torr more}$$

$$P_2 = \frac{P_1 T_2}{T_1} = \frac{(660 \text{ torr})(318 \text{ K})}{295 \text{ K}} = 711 \text{ torr}$$

$$T_2 = 44.6^\circ\text{C} + 273 = 318 \text{ K}$$

$$Solutions \quad 939$$

## Chapter 13

$$\text{Rate}_{\text{neon}} = \sqrt{\frac{20.2 \text{ g/mole}}{28.0 \text{ g/mole}}} = \sqrt{0.721} = 0.849$$

$$\text{Rate}_{\text{carbon dioxide}} = \sqrt{\frac{44.0 \text{ g/mole}}{28.0 \text{ g/mole}}} = \sqrt{1.57} = 1.25$$

3. Rearrange Graham's law to solve for RateA.

$$\text{Rate}_A = \text{Rate}_B \times \frac{\text{molar mass}_B}{\text{molar mass}_A}$$

$$= 3.6 \text{ mol/min} \times \frac{0.5}{0.5} = 3.6 \text{ mol/min}$$

$$= 2.5 \text{ mol/min}$$

$$= 161 \text{ mm Hg}$$

$$= 600 \text{ mm Hg} - 439 \text{ mm Hg}$$

$$= 13.78 \text{ kPa}$$

$$6. P_{\text{carbon dioxide}} = 30.4 \text{ kPa} - (16.5 \text{ kPa} + 3.7 \text{ kPa}) = 30.4 \text{ kPa} - 20.2 \text{ kPa} = 10.2 \text{ kPa}$$

$$5. P_{\text{total}} = 5.00 \text{ kPa} + 4.56 \text{ kPa} + 3.02 \text{ kPa} + 1.20 \text{ kPa}$$

$$= 161 \text{ mm Hg}$$

$$4. P_{\text{hydrogen}} = P_{\text{total}} - P_{\text{helium}}$$

$$= 13.78 \text{ kPa}$$

$$= 161 \text{ mm Hg}$$

$$3. P_{\text{total}} = 1.00 \text{ atm} = 101.3 \text{ kPa}$$

$$2. V_2 = \frac{P_1 V_1}{P_2} = \frac{(0.220 \text{ L})(0.860 \text{ atm})}{0.288 \text{ atm}} = 0.657 \text{ L}$$

$$1. T_2 = 30.0^\circ\text{C} + 273 = 303 \text{ K}$$

$$V_2 = \frac{V_1 T_2}{T_1} = \frac{(3.00 \text{ L})(303 \text{ K})}{298 \text{ K}} = 2.58 \text{ L}$$

$$8. T_1 = 25.0^\circ\text{C} + 273 = 298 \text{ K}$$

$$T_2 = 0.00^\circ\text{C} + 273 = 273 \text{ K}$$

$$V_2 = \frac{V_1 T_2}{T_1} = \frac{(0.620 \text{ L})(273 \text{ K})}{298 \text{ K}} = 0.57 \text{ L}$$

$$9. T_1 = 30.0^\circ\text{C} + 273 = 303 \text{ K}$$

$$T_2 = \frac{P_1 T_1}{P_2} = \frac{(303 \text{ K})(201 \text{ kPa})}{125 \text{ kPa}} = 487 \text{ K}$$

$$10. T_1 = 25.0^\circ\text{C} + 273 = 298 \text{ K}$$

$$T_2 = 37.0^\circ\text{C} + 273 = 310 \text{ K}$$

$$P_2 = \frac{P_1 T_2}{T_1} = \frac{(1.88 \text{ atm})(310 \text{ K})}{298 \text{ K}} = 1.96 \text{ atm}$$

$$11. T_2 = 36.5^\circ\text{C} + 273 = 309.5 \text{ K}$$

$$T_1 = \frac{P_2 T_2}{P_1} = \frac{(309.5 \text{ K})(1.12 \text{ atm})}{2.56 \text{ atm}} = 135 \text{ K}$$

$$12. T_1 = 0.00^\circ\text{C} + 273 = 273 \text{ K}$$

$$T_2 = \frac{P_1 T_1}{P_2} = \frac{(660 \text{ torr})(318 \text{ K})}{295 \text{ K}} = 711 \text{ torr}$$

$$711 \text{ torr} - 660 \text{ torr} = 51 \text{ torr more}$$

$$7. The temperature must be lowered by 21^\circ\text{C}.$$

$$6. 252.5 \text{ K} - 273 = -20.5^\circ\text{C} = -21^\circ\text{C}$$

$$Solutions \quad 939$$

## Chapter 14

## APPENDIX D Solutions to Practice Problems

**19.**  $T_1 = 36^\circ\text{C} + 273 = 309 \text{ K}$

$$T_2 = 28^\circ\text{C} + 273 = 301 \text{ K}$$

$$V_2 = \frac{P_1 T_2 V_1}{P_2 T_1} = \frac{(0.998 \text{ atm})(301 \text{ K})(2.1 \text{ L})}{(0.900 \text{ atm})(309 \text{ K})} = 2.3 \text{ L}$$

**20.**  $T_1 = 0.00^\circ\text{C} + 273 = 273 \text{ K}$

$$T_2 = 30.00^\circ\text{C} + 273 = 303 \text{ K}$$

$$P_2 = \frac{V_1 T_2 P_1}{V_2 T_1} = \frac{(30.0 \text{ mL})(303 \text{ K})(1.00 \text{ atm})}{(20.0 \text{ mL})(273 \text{ K})} = 1.66 \text{ atm}$$

**21.**  $T_1 = 22.0^\circ\text{C} + 273 = 295 \text{ K}$

$$T_2 = 100.0^\circ\text{C} + 273 = 373 \text{ K}$$

$$V_1 = \frac{V_2 T_1 P_2}{T_2 P_1} = \frac{(0.224 \text{ mL})(295 \text{ K})(1.23 \text{ atm})}{(373 \text{ K})(1.02 \text{ atm})} = 0.214 \text{ mL}$$

**22.**  $T_1 = 5.0^\circ\text{C} + 273 = 278 \text{ K}$

$$T_2 = 2.09^\circ\text{C} + 273 = 275 \text{ K}$$

$$V_2 = \frac{P_1 T_2 V_1}{P_2 T_1} = \frac{(1.30 \text{ atm})(275 \text{ K})(46.0 \text{ mL})}{(1.52 \text{ atm})(278 \text{ K})} = 39 \text{ mL}$$

**23.**  $P_1 = \frac{V_2 T_1 P_2}{V_1 T_2} = \frac{(0.644 \text{ L})(298 \text{ K})(32.6 \text{ kPa})}{(0.766 \text{ L})(303 \text{ K})} = 27.0 \text{ kPa}$

**24.**  $2.4 \text{ mol} \times \frac{22.4 \text{ L}}{\text{mol}} = 54 \text{ L}$

**25.**  $0.0459 \text{ mol} \times \frac{22.4 \text{ L}}{\text{mol}} = 1.03 \text{ L}$

**26.**  $1.02 \text{ mol} \times \frac{22.4 \text{ L}}{\text{mol}} = 22.8 \text{ L}$

**27.**  $2.00 \text{ L} \times \frac{1 \text{ mol}}{22.4 \text{ L}} = 0.0893 \text{ mol}$

**28.** Set up problem as a ratio.

$$\frac{\text{? mol He}}{0.865 \text{ L}} = \frac{0.0226 \text{ mol He}}{0.460 \text{ L}}$$

Solve for mol He.

$$\text{? mol He} = \frac{0.0226 \text{ mol He}}{0.460 \text{ L}} \times 0.865 \text{ L} = 0.0425 \text{ mol He}$$

**29.**  $1.0 \text{ L} \times \frac{1 \text{ mol}}{22.4 \text{ L}} = 0.045 \text{ mol}$

$$0.045 \text{ mol} \times \frac{44.0 \text{ g}}{\text{mol}} = 2.0 \text{ g}$$

**30.**  $0.00922 \text{ g} \times \frac{1 \text{ mol}}{2.016 \text{ g}} = 0.00457 \text{ mol}$

$$0.00457 \text{ mol} \times \frac{22.4 \text{ L}}{\text{mol}} = 0.102 \text{ L or } 102 \text{ mL}$$

**31.**  $0.416 \text{ g} \times \frac{1 \text{ mol}}{83.8 \text{ g}} = 0.00496 \text{ mol}$

$$0.00496 \text{ mol} \times \frac{22.4 \text{ L}}{\text{mol}} = 0.111 \text{ L}$$

**32.**  $0.860 \text{ g} - 0.205 \text{ g} = 0.655 \text{ g He remaining}$

Set up problem as a ratio.

$$\frac{V}{0.655 \text{ g}} = \frac{19.2 \text{ L}}{0.860 \text{ g}}$$

Solve for V.

$$V = \frac{(19.2 \text{ L})(0.655 \text{ g})}{0.860 \text{ g}} = 14.6 \text{ L}$$

**33.**  $4.5 \text{ kg} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ mol}}{28.0 \text{ g}} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 3.6 \times 10^3 \text{ L}$

**41.**  $n = \frac{PV}{RT} = \frac{(3.81 \text{ atm})(0.44 \text{ L})}{(0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})(298 \text{ K})} = 6.9 \times 10^{-3} \text{ mol}$

**42.**  $143 \text{ kPa} \times \frac{1.00 \text{ atm}}{101.3 \text{ kPa}} = 1.41 \text{ atm}$

$$T = \frac{PV}{nR} = \frac{(1.41 \text{ atm})(1.00 \text{ L})}{(2.49 \text{ mol})(0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})} = 6.90 \text{ K}$$

$$6.90 \text{ K} - 273 = -266^\circ\text{C}$$

**43.**  $V = \frac{nRT}{P} = \frac{(0.323 \text{ mol})(0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})(265 \text{ K})}{0.900 \text{ atm}} = 7.81 \text{ L}$

**44.**  $T = 20.0^\circ\text{C} + 273 = 293 \text{ K}$

$$P = \frac{nRT}{V} = \frac{(0.108 \text{ mol})(0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})(293 \text{ K})}{0.505 \text{ L}} = 5.14 \text{ atm}$$

**45.**  $T = \frac{PV}{nR} = \frac{(0.988 \text{ atm})(1.20 \text{ L})}{(0.0470 \text{ mol})(0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})} = 307 \text{ K}$

**46.**  $117 \text{ kPa} \times \frac{1.00 \text{ atm}}{101.3 \text{ kPa}} = 1.15 \text{ atm}$

$$T = 35.1^\circ\text{C} + 273 = 308 \text{ K}$$

$$m = \frac{PMV}{RT} = \frac{(1.15 \text{ atm})(70.0 \text{ g/mol})(2.00 \text{ L})}{(0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})(308 \text{ K})} = 6.39 \text{ g}$$

**47.**  $T = 22.0^\circ\text{C} + 273 = 295 \text{ K}$

$$m = \frac{MPV}{RT} = \frac{(28.0 \text{ g/mol})(1.00 \text{ atm})(0.600 \text{ L})}{(0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})(295 \text{ K})} = 0.694 \text{ g}$$

## APPENDIX D Solutions to Practice Problems

### Solutions

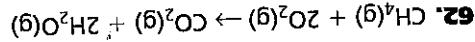
Solutions 941



$$0.271 \text{ mol CH}_4 \times \frac{1 \text{ mol H}_2\text{O}}{2 \text{ mol H}_2\text{O}} = 0.541 \text{ mol H}_2\text{O}$$

$$= 0.271 \text{ mol CH}_4$$

$$n = \frac{PV}{RT} = \frac{(0.0821 \text{ L-atm})(10.5 \text{ K})}{(1.00 \text{ atm})(10.5 \text{ K})} = 0.0821 \text{ mol-K}$$



$$1 \text{ mol CH}_4 \times \frac{1 \text{ mol CO}_2}{1 \text{ mol CH}_4} \times \frac{22.4 \text{ L}}{1 \text{ mol CO}_2} = 53.3 \text{ L CO}_2$$

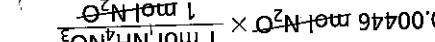
$$61. 2.38 \text{ kg} \times \frac{1000 \text{ g}}{\text{kg}} \times \frac{1 \text{ mol C}_2\text{H}_5}{1 \text{ mol C}_2\text{H}_3} \times \frac{22.4 \text{ L}}{1 \text{ mol C}_2\text{H}_3} \times \frac{100.0 \text{ g}}{1 \text{ mol C}_2\text{H}_5} = 0.357 \text{ g NH}_4\text{NO}_3$$

$$= 0.00446 \text{ mol NH}_4\text{NO}_3 \times 80.0 \text{ g/mol} = 0.00446 \text{ mol NH}_4\text{NO}_3$$

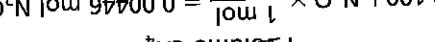
$$0.00446 \text{ mol N}_2\text{O} \times \frac{1 \text{ mol NH}_4\text{NO}_3}{1 \text{ mol N}_2\text{O}} = 0.00446 \text{ mol NH}_4\text{NO}_3$$

$$60. 0.100 \text{ L N}_2\text{O} \times \frac{1 \text{ mol}}{22.4 \text{ L}} = 0.00446 \text{ mol N}_2\text{O}$$

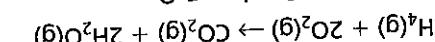
$$2.36 \text{ L CH}_4 \times \frac{1 \text{ mole}}{2 \text{ volumes O}_2} = 4.72 \text{ L O}_2$$



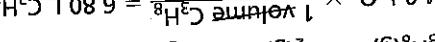
$$34.0 \text{ L O}_2 \times \frac{1 \text{ volume C}_3\text{H}_8}{5 \text{ volumes O}_2} = 6.80 \text{ L C}_3\text{H}_8$$



$$5.00 \text{ L O}_2 \times \frac{1 \text{ volume H}_2}{2 \text{ volumes H}_2} = 10.0 \text{ L H}_2$$



$$3.5 \text{ L SO}_2 \times \frac{1 \text{ volume SO}_2}{1 \text{ volume O}_2} = 3.5 \text{ L O}_2$$



$$M = \frac{RT}{P} = \frac{(0.0821 \text{ L-atm})(273 \text{ K})}{(1.09 \text{ g/L})(1.00 \text{ atm})} = 1.78 \text{ g/L}$$

$$= 26.1 \text{ g/mol}$$

$$49. T = 25.0^\circ\text{C} + 273 = 298 \text{ K}$$

$$D = \frac{PM}{RT} = \frac{1.02 \text{ atm}}{(1.09 \text{ g/L})(0.0821 \text{ L-atm})(298 \text{ K})} = 1.96 \text{ g/L}$$

$$= 1.96 \text{ g/L}$$

$$48. D = \frac{PM}{RT} = \frac{(1.00 \text{ atm})(44.0 \text{ g/mol})}{(0.0821 \text{ L-atm})(273 \text{ K})} = 1.96 \text{ g/L}$$

$$= 1.96 \text{ g/L}$$

$$63. 52.0 \text{ g Fe} \times \frac{1 \text{ mol Fe}}{55.85 \text{ g Fe}} \times \frac{3 \text{ mol O}_2}{4 \text{ mol Fe}} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 15.6 \text{ L O}_2$$

$$64. 2\text{K}(\text{s}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{KCl}(\text{s})$$

$$0.204 \text{ g K} \times \frac{1 \text{ mol K}}{39.1 \text{ g K}} \times \frac{1 \text{ mol Cl}_2}{1 \text{ mol K}} \times \frac{22.4 \text{ L}}{1 \text{ mol Cl}_2} = 0.0584 \text{ L Cl}_2$$